PB83-183277

Additional Techniques for Estimating MOBILE2 Variables

Energy and Environmental Analysis, Inc.
Arlington, VA

Prepared for

Environmental Protection Agency
Ann Arbor, MI

Nov 80

U.S. Department of Commerce
National Technical Information Service
NTIS

PB83-183277

ADDITIONAL TECHNIQUES FOR ESTIMATING MOBILE2 VARIABLES

EPA Contract No. 68-03-2888

Prepared for:

TEST AND EVALUATION BRANCH
EMISSION CONTROL TECHNOLOGY DIVISION
OFFICE OF MOBILE SOURCE AIR POLLUTION CONTROL
OFFICE OF AIR, NOISE, AND RADIATION
U.S. ENVIRONMENTAL PROTECTION AGENCY
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November 1980

REPRODUCED BY
NATIONAL TECHNICAL
INFORMATION SERVICE
U.S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA. 22161

TECHNICAL REPORT DATA
(Please read Instructions on the reverse before completing)

1. REPORT NO.	2.	3. RECIPIENT'S ACCESSION NO.
		PB83-183277

4. TITLE AND SUBTITLE
Additional Techniques for Estimating MOBILE2 Variables.

5. REPORT DATE

6. PERFORMING ORGANIZATION CODE

7. AUTHOR(S)

8. PERFORMING ORGANIZATION REPORT NO.

9. PERFORMING ORGANIZATION NAME AND ADDRESS
Energy and Environmental Analysis, Inc.
1111 North 19th Street
Arlington, Virginia 22209

10. PROGRAM ELEMENT NO.

11. CONTRACT/GRANT NO.
68-03-2888

12. SPONSORING AGENCY NAME AND ADDRESS
United States Environmental Protection Agency
Office of Mobile Source Air Pollution Control
Test and Evaluation Branch
Ann Arbor, MI 48105

13. TYPE OF REPORT AND PERIOD COVERED
Technical

14. SPONSORING AGENCY CODE

15. SUPPLEMENTARY NOTES

16. ABSTRACT

This report describes techniques that can be used to estimate three MOBILE2 input variables: speed, average miles driven per day per vehicle, and air conditioning usage as a function of ambient conditions. These techniques are needed so that users from state and local agencies can use MOBILE2 to produce mobile source emission factor estimates appropriate to their particular area.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Air Pollution Air Quality Computer Programming Emission Factors Exhaust Emissions Mathematical Models Mobile Source Emissions Model Motor Vehicles	MOBILE2 Computer Program Regulations Variables	

18. DISTRIBUTION STATEMENT	19. SECURITY CLASS *(This Report)*	21. NO. OF PAGES
Release Unlimited	unclassified	55
	20. SECURITY CLASS *(This page)*	22. PRICE
	unclassified	

EPA Form 2220-1 (9-73)

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1. INTRODUCTION

The purpose of this report is to describe work performed by EEA, Inc. for Task Order No. 4 of EPA Contract No. 68-03-2888. This report supplements work performed for Task Order No. 1 of this same contract. The objective of both task orders was to develop a general users information package for selected MOBILE2 input variables. Specifically, estimation techniques are needed so that users of MOBILE2 can produce mobile source emission factor estimates appropriate to their particular areas. This report describes techniques that can be used to estimate three MOBILE2 input variables: speed, average miles driven per day per vehicle, and air conditioning usage as a function of ambient conditions. Estimation techniques for nine other MOBILE2 input variables were presented previously in the final report for Task Order No. 1. The techniques presented in each of these reports were developed to assist users in estimating values for the input variables to MOBILE2 in which data and techniques are not locally available or have not yet been developed. Note that where locally developed estimates are available, they should be used instead of the techniques presented here.

Table 1-1 shows the MOBILE2 input variables and vehicle types discussed in this report. The vehicle type abbreviations shown at the bottom of the table are those used throughout the report. The report is organized so that estimation techniques for each variable are presented in separate sections. Within each section, estimation techniques are presented separately for each vehicle type. In some cases, more than one possible estimation technique is described for each vehicle type. In those cases, MOBILE2 users can choose the technique most appropriate for their situation.

TABLE 1-1

SELECT MOBILE2 INPUT VARIABLES BY VEHICLE TYPE

Input Variables	Vehicle Type*
11. Speed	All vehicle types
12. Vehicle miles/day	All vehicle types
13. Air conditioning usage as a function of ambient conditions	All except MC, HDGV, and HDDV

*LDGV: Light-Duty Gasoline-Powered Vehicles

LDDV: Light-Duty Diesel-Powered Vehicles

LDGT1: Light-Duty Gasoline-Powered Trucks (<6001 lbs. GVW)

LDGT2: Light-Duty Gasoline-Powered Trucks (>6000 and <8501 lbs. GVW)

LDDT: Light-Duty Diesel-Powered Trucks (<8501 lbs. GVW)

HDGV: Heavy-Duty Gasoline-Powered Vehicles (>8500 lbs. GVW)

HDDV: Heavy-Duty Diesel-Powered Vehicles (>8500 lbs. GVW)

MC: Motorcycles

The data sources used to provide the information presented in the next three sections are, for the most part, generally available to any user. These sources are identified in the last page of each section. This report also draws heavily from the final report of Task Order No. 1 of this contract. Material from that report is not repeated here. Instead, the appropriate section in the Task Order No. 1 report is referenced in the text. Therefore, in order to apply the techniques presented, both reports are needed. In some cases, state or local agencies have been contacted to obtain examples of data which are typically available for a given variable. These are mentioned in the text.

11. SPEED BY VEHICLE TYPE AND ROAD TYPE

This section presents general techniques for estimating speed by vehicle type and road type. The specific speed estimates used should be chosen based on the time period for which emission estimates are derived. This time period might range from a specific hour to an annual average. Thus, the MOBILE2 user should be sure that the time period used to estimate vehicle speeds matches the data requirements of the emissions or air quality analysis being performed.

For instance, if speed data are needed to estimate hydrocarbon emissions for an ozone analysis, the complexity of the analysis dictates the type of speed data needed. The most complex situation is one in which hourly emission estimates are needed for a grid-based photochemical model. In that case, an urban tranportation planning model is used to determine spatial and temporal variations in traffic. In the process of running this model, speeds are determined for each link, and therefore emission factors are needed for each of these speeds. For a less complex ozone modeling situation, emission estimates may be needed for 6-9 a.m. or an entire day. Vehicle speeds should be estimated for corresponding periods.

Whenever local data on vehicle speeds are available, the user should employ these data. Local Councils of Government (COG), regional planning agencies, or city traffic departments often collect speed data for their particular metropolitan area or city. When local data are <u>not</u> available, the user can turn to state level information or to the generalized urban speed data presented in this document.

In selecting average speed data for use in an air quality model, there are two important distinctions to be kept in mind:

- Urban or rural
- For urban speeds: peak or off-peak.

Urban speed data often include average figures for both highway speeds and arterial and collector street speeds. Rural speeds are collected for different highway categories. The primary distinction between urban and rural speeds is the peaking phenomenon associated with urban speeds. Average speeds in an urban area are necessarily slower during morning and evening rush hours due to heavy commuter travel. Average rural speeds are relatively constant, except for slightly lower average speeds after dark due to reduced driver visibility. This discussion of average speeds by vehicle type will address data sources by location (urban or rural).

11.1 ALL VEHICLES EXCEPT TRANSIT BUSES: URBAN SPEEDS

The following subsections identify data sources for urban vehicle speeds and discuss some of the data limitations. Urban vehicle speeds are not broken down into vehicle type components, except in the case of transit buses, because detailed speed data of that nature are not generally available. The lack of urban speed data by vehicle type should not alarm the MOBILE2 user. The density and stop-and-go nature of urban traffic generally result in platoons of vehicles traveling together between stoplights or interchanges with little variation between vehicle types. Most urban traffic is comprised of cars, and light-duty trucks and buses. Since there is speed information on transit buses operating in local service, urban bus speeds are treated separately in this report (see Section 11.2). Section 11.1.2 addresses important issues in data interpretation.

11.1.1 Data Sources

Many metropolitan planning agencies collect speed data for use in travel demand models. Some city traffic departments perform speed and delay

studies for the purpose of traffic engineering analysis. Finally, state highway departments collect speed data on urban highways and occasionally on city streets. The Surface Transportation Assistance Act of 1978 requires State Departments of Transportation to measure speeds on several types of highways.

Travel demand speed data are usually disaggregated by vehicle type and often by road type. Speed and delay data are nearly always disaggregated by road type but often not by vehicle type.

The Southeastern (Michigan) Council of Governments recently conducted a speed and delay study and provides average vehicle speeds by roadway type and time of day for the Detroit metropolitan area. The data are not disaggregated by vehicle type.

The Colorado Department of Highways provides average vehicle speeds for the following roadway types in the Denver metropolitan area:

- Freeway
- Expressway
- Principal arterial
- Minor arterial
- Collector

These data are collected for the a.m. peak, p.m. peak, and off-peak hours in each of several locations. However, there is no indication in the Denver Travel Time Monitoring Document of the time at which the a.m. and p.m. peak travel hours occur. Since these peaks may vary from one urban area to another, the user should determine when peak travel occurs in a particular locality. The Denver data are not disaggregated by vehicle type.

Regional planning agencies that do not collect urban speed data locally usually rely upon information in a document entitled Characteristics of Urban Transportation Systems: A Handbook for Transportation Planners. The "CUTS" manual reports roadway capacity and average speed per lane for all vehicle types by location of facility. Using knowledge of local roadway conditions, a MOBILE2 user can select, from Table 11-1, the most appropriate average vehicle speeds for the local volume-to-capacity conditions. The CUTS manual is revised annually to reflect changes in traffic speed trends. It is available through the Urban Mass Transportation Administration (UMTA) or a regional planning agency library.

Average urban speeds on interstate highways are reported for each state in Table 11-2. These are free flow speeds and do not account for peak hour delays. The speeds are measured annually by State transportation agencies and reported by the Federal Highway Administration (FHWA) of the U.S. DOT.

11.1.2 Data Interpretation

Depending on the nature of the air quality problem, a MOBILE2 user might wish to have the data regarding average vehicle speeds during a particular time of day, or an average speed over a 24 hour time period. Both the Detroit and Denver data present speeds by time of day. In order to calculate peak-hour average speeds using CUTS data a user could develop a ratio of peak-hour average speed to 24-hour average speed in one or both of these metropolitan areas. The important point to keep in mind is that the user should be aware of the time-dependent nature of urban vehicle speed data, whether they are collected locally or elsewhere.

11.2 TRANSIT BUSES: URBAN SPEEDS

Due to the nature of transit bus trips, picking up and dropping off passengers, transit bus speeds are generally lower than those of other

TABLE 11-1

ROADWAY CAPACITY AND AVERAGE SPEED PER LANE FOR ROADWAYS IN VARIOUS URBAN LOCATIONS

Facility Type	Location*							
	Central Business District Roadway Capacity**		Fringe Roadway Capacity**		Residential Roadway Capacity**		Outlying Business District Roadway Capacity**	
	Ratio of Traffic Volume to Roadway Capacity	Speed† (MPH)	Ratio of Traffic Volume to Roadway Capacity	Speed† (MPH)	Ratio of Traffic Volume to Roadway Capacity	Speed† (MPH)	Ratio of Traffic Volume to Roadway Capacity	Speed† (MPH)
	1750 VPH††		1750 VPH		1750 VPH		1750 VPH	
Freeway	0.00	48	0.00	48	0.00	67	0.00	58
	0.50	38	0.50	38	0.50	57	0.50	48
	0.75	33	0.75	33	0.75	50	0.75	41
	1.00	28	1.00	28	1.00	34	1.00	30
	800 VPH		1000 VPH		1100 VPH		1000 VPH	
Expressway	0.00	37	0.00	44	0.00	47	0.00	37
	0.50	34	0.50	38	0.50	44	0.50	34
	0.75	33	0.75	35	0.75	41	0.75	33
	1.00	31	1.00	32	1.00	38	1.00	31
	400 VPH		550 VPH		550 VPH		550 VPH	
Arterial Two-Way With Parking	0.00	17-22	0.00	25-29	0.00	28-32	0.00	22-24
	0.50	17-20	0.50	20-27	0.50	25-30	0.50	20-22
	0.75	15-15	0.75	18-25	0.75	23-28	0.75	18-18
	1.00	12-12	1.00	15-15	1.00	15-15	1.00	13-13

TABLE 11-1 (cont'd.)

CAPACITY AND AVERAGE SPEED ON VARIOUS ROADWAYS PER LANE

Facility Type	Location*							
	Central Business District Roadway Capacity**		Fringe Roadway Capacity**		Residential Roadway Capacity**		Outlying Business District Roadway Capacity**	
	Ratio of Traffic Volume to Roadway Capacity	Speed† (MPH)	Ratio of Traffic Volume to Roadway Capacity	Speed† (MPH)	Ratio of Traffic Volume to Roadway Capacity	Speed† (MPH)	Ratio of Traffic Volume to Roadway Capacity	Speed† (MPH)
	600 VPH††		800 VPH		800 VPH		800 VPH	
Arterial Two-Way Without Parking	0.00	17-22	0.00	25-29	0.00	28-32	0.00	22-24
	0.50	17-20	0.50	20-27	0.50	25-30	0.50	20-22
	0.75	15-15	0.75	18-25	0.75	23-28	0.75	18-18
	1.00	12-12	1.00	15-15	1.00	15-15	1.00	13-13
	700 VPH		550 VPH		900 VPH		650 VPH	
Arterial One-Way	0.00	17-22	0.00	25-29	0.00	28-32	0.00	22-24
	0.50	17-20	0.50	20-27	0.50	25-30	0.50	20-22
	0.75	15-15	0.75	18-25	0.75	23-28	0.75	18-18
	1.00	12-12	1.00	15-15	1.00	15-15	1.00	13-13

* These roadway locations are based on urban development definitions originally introduced in the Highway Capacity Manual (U.S. Department of Commerce; Bureau of Public Roads: 1950). The CBD is the area of a city of greatest concentration - the "downtown;" the fringe is outside of the downtown area but within the influence of business development; residential and outlying business districts are furthest from center city and, thus, assumed to be least congested.

** Capacity calculated at level of service E (absolute capacity). The assumption is that a maximum number of vehicles pass over the roadway during a specified period.

† First value shows speed assuming a lack of coordinated signal progression; second value shows speed assuming full signal progression.

†† VPH = Vehicles per hour.

SOURCE: Characteristics of Urban Transportation Systems: A Handbook for Transportation Planners, prepared by DeLeuw, Cather & Co. for Urban Mass Transportation Administration, U.S. DOT, 1979.

FREE FLOW SPEED DATA -- OCTOBER 1977 - SEPTEMBER 1978

(BASED ON STATE CERTIFICATION REPORTS FOR FISCAL YEAR 1978)

HIGHWAY STATISTICS DIVISION
OFFICE OF HIGHWAY PLANNING, FHWA.

TABLE VS-1
OCTOBER 1979

REGION AND STATE	INTERSTATE URBAN						INTERSTATE RURAL						MULTI-LANE DIVIDED						MULTI-LANE UNDIVIDED						2-LANE RURAL					
	AVER. SPEED	MEDIAN SPEED 1/	85TH PER-CENT SPEED 2/	PERCENT EXCEEDING 55 MPH	60 MPH	65 MPH	AVER. SPEED	MEDIAN SPEED 1/	85TH PER-CENT SPEED 2/	PERCENT EXCEEDING 55 MPH	60 MPH	65 MPH	AVER. SPEED	MEDIAN SPEED 1/	85TH PER-CENT SPEED 2/	PERCENT EXCEEDING 55 MPH	60 MPH	65 MPH	AVER. SPEED	MEDIAN SPEED 1/	85TH PER-CENT SPEED 2/	PERCENT EXCEEDING 55 MPH	60 MPH	65 MPH	AVER. SPEED	MEDIAN SPEED 1/	85TH PER-CENT SPEED 2/	PERCENT EXCEEDING 55 MPH	60 MPH	65 MPH
1 CONNECTICUT	57.8	57.0	62.3	67	28	7	59.2	58.6	63.8	75	38	11	57.9	57.1	62.5	66	28	8	3/	3/	3/	3/	3/	3/	3/	3/	3/	3/	3/	3/
MAINE	55.7	55.1	60.9	51	18	4	59.2	58.6	63.7	77	39	10	58.2	57.5	63.4	68	33	9	3/	3/	3/	3/	3/	3/	52.9	52.4	58.1	31	9	2
MASSACHUSETTS	55.8	55.8	60.6	52	18	3	56.6	56.4	60.9	58	24	3	55.7	55.8	61.0	50	18	4	3/	3/	3/	3/	3/	3/	55.1	55.1	59.6	45	11	2
NEW HAMPSHIRE	55.0	54.1	59.4	43	17	2	58.4	57.3	62.7	67	36	8	57.7	56.5	61.7	62	30	5	3/	3/	3/	3/	3/	3/	53.3	52.1	57.6	28	10	2
NEW JERSEY	55.6	55.1	59.6	51	13	2	56.0	55.5	59.8	56	15	2	54.8	54.4	59.2	45	13	2	3/	3/	3/	3/	3/	3/	53.0	53.1	58.7	39	12	3
NEW YORK	58.2	58.2	62.9	73	35	9	58.7	58.6	63.4	77	39	10	55.0	55.3	60.5	53	18	4	51.6	52.9	57.6	30	8	1	43.7	42.0	49.3	5	1	0
RHODE ISLAND	57.4	58.2	62.9	65	28	8	57.9	58.7	63.0	70	31	9	55.1	55.7	60.8	48	17	5	3/	3/	3/	3/	3/	3/	3/	3/	3/	3/	3/	3/
VERMONT	3/	3/	3/	3/	3/	3/	58.4	58.3	63.6	73	33	9	3/	3/	3/	3/	3/	3/	3/	3/	3/	3/	3/	3/	3/	3/	3/	3/	3/	3/
PUERTO RICO	3/	3/	3/	3/	3/	3/	3/	3/	3/	3/	3/	3/	52.3	51.1	59.3	34	12	5	3/	3/	3/	3/	3/	3/	3/	3/	3/	3/	3/	3/
3 DELAWARE	58.3	58.2	62.5	72	37	11	3/	3/	3/	3/	3/	3/	56.3	56.4	62.5	60	24	6	3/	3/	3/	3/	3/	3/	3/	3/	3/	3/	3/	3/
MARYLAND	56.0	56.0	61.0	55	16	2	57.5	58.0	62.0	67	25	4	56.7	57.0	61.0	60	21	3	54.9	55.0	60.0	45	11	1	52.7	53.0	57.0	27	5	1
PENNSYLVANIA	58.7	58.2	62.9	78	36	10	59.3	58.8	62.9	83	41	10	56.5	56.0	61.1	61	23	6	51.9	53.6	58.5	41	11	3	54.1	53.6	59.0	44	14	4
VIRGINIA	57.2	57.0	62.0	65	22	5	58.9	59.0	64.0	76	36	10	55.0	55.0	61.0	49	16	3	53.4	54.0	59.0	38	5	1	51.1	51.0	57.0	28	11	2
WEST VIRGINIA	56.3	56.3	60.8	61	20	3	58.2	58.2	62.7	74	33	7	57.0	56.8	61.3	66	24	5	3/	3/	3/	3/	3/	3/	56.2	55.0	59.4	45	12	2
DIST. OF COL.	4/	4/	4/	4/	4/	4/	3/	3/	3/	3/	3/	3/	3/	3/	3/	3/	3/	3/	3/	3/	3/	3/	3/	3/	3/	3/	3/	3/	3/	3/
4 ALABAMA	56.9	57.0	62.4	65	27	7	59.9	59.6	65.5	82	45	17	56.1	56.1	61.8	59	24	6	3/	3/	3/	3/	3/	3/	56.0	56.3	61.0	46	18	6
FLORIDA	55.8	55.9	62.1	54	20	4	58.9	58.8	64.4	75	37	10	56.3	56.5	62.3	57	23	6	4/	4/	4/	4/	4/	4/	55.6	55.5	62.4	51	22	7
GEORGIA	60.2	59.3	63.6	77	42	6	62.2	61.2	66.3	85	59	15	58.6	57.6	63.4	61	33	7	4/	4/	4/	4/	4/	4/	56.9	55.9	61.8	49	23	4
KENTUCKY	56.9	56.8	62.1	62	24	5	61.1	61.1	67.0	85	51	20	56.9	56.9	63.0	59	28	9	3/	3/	3/	3/	3/	3/	51.7	51.9	58.2	30	10	3
MISSISSIPPI	57.0	56.0	61.9	58	25	7	61.6	61.5	66.2	84	54	20	59.3	58.5	63.4	75	38	10	3/	3/	3/	3/	3/	3/	55.6	55.0	61.9	51	25	8
NORTH CAROLINA	57.5	57.0	61.0	69	20	4	59.0	59.0	63.0	81	32	7	56.8	56.0	61.0	63	19	3	4/	4/	4/	4/	4/	4/	53.7	54.0	59.0	39	10	2
SOUTH CAROLINA	58.6	58.2	62.2	78	32	5	59.9	59.4	63.5	86	44	8	56.5	56.4	60.7	62	19	3	4/	4/	4/	4/	4/	4/	55.6	55.6	59.7	55	13	2
TENNESSEE	52.9	54.9	60.2	41	9	3	59.0	60.4	67.7	78	40	20	53.4	55.2	60.9	43	10	4	52.8	54.2	62.2	39	15	9	52.8	56.4	63.0	41	17	9
5 ILLINOIS	58.5	58.3	64.1	66	31	9	59.2	58.6	63.5	78	36	9	57.5	56.9	62.5	63	26	7	55.9	55.2	61.5	52	20	5	55.3	56.8	61.0	48	18	5
INDIANA	58.3	57.7	62.5	74	31	7	60.0	59.3	64.5	84	43	13	57.4	57.0	62.1	65	26	6	4/	4/	4/	4/	4/	4/	56.2	55.7	61.3	35	21	6
MICHIGAN	56.4	56.0	61.5	57	21	5	57.8	58.0	62.4	69	27	6	57.6	58.0	61.5	68	27	5	52.6	53.0	57.5	33	8	1	54.7	55.0	59.5	46	15	3
MINNESOTA	56.4	55.8	60.0	59	15	2	58.3	57.6	61.8	76	27	5	56.5	56.1	60.3	60	17	3	3/	3/	3/	3/	3/	3/	56.5	55.9	60.7	58	18	4
OHIO	58.3	58.5	63.0	75	36	9	58.3	58.3	63.1	75	36	9	56.6	56.5	61.3	63	23	5	4/	4/	4/	4/	4/	4/	54.9	54.7	60.7	48	19	5
WISCONSIN	58.5	58.5	63.2	85	35	5	58.1	58.1	62.8	79	31	5	57.2	57.2	62.1	72	25	4	3/	3/	3/	3/	3/	3/	55.0	55.1	60.5	52	16	3
6 ARKANSAS	56.5	56.7	61.7	56	25	3	60.2	60.3	65.4	81	52	12	57.6	57.9	63.5	64	34	7	4/	4/	4/	4/	4/	4/	53.5	54.3	61.0	40	19	4
LOUISIANA	55.5	54.3	60.1	46	12	3	56.9	55.8	61.0	52	17	6	55.7	54.1	60.0	45	12	4	4/	4/	4/	4/	4/	4/	52.2	51.3	57.4	28	8	2
NEW MEXICO	55.3	54.8	62.6	47	18	6	59.3	59.9	68.3	73	42	16	56.2	57.1	61.8	57	23	6	4/	4/	4/	4/	4/	4/	57.8	59.0	65.9	66	34	14
OKLAHOMA	58.8	59.0	64.0	74	37	10	60.3	60.0	66.0	82	47	17	57.6	58.0	63.0	66	30	9	58.7	58.0	65.0	71	36	12	56.6	57.0	62.0	59	25	7
TEXAS	59.4	60.4	65.9	78	39	14	61.1	61.8	68.6	85	48	23	60.6	61.5	67.3	82	47	20	58.5	60.0	65.1	71	34	13	59.2	60.0	67.5	74	38	20
7 IOWA	55.8	56.2	60.6	53	13	1	58.3	58.7	63.3	75	30	6	57.4	57.9	62.2	70	23	4	4/	4/	4/	4/	4/	4/	55.9	56.5	61.2	55	16	3
KANSAS	57.3	57.6	61.9	68	22	3	58.8	58.5	63.0	77	31	8	57.7	57.7	62.3	70	26	6	4/	4/	4/	4/	4/	4/	58.5	58.1	63.3	73	34	11
MISSOURI	57.1	57.0	60.0	68	15	2	59.8	60.0	64.0	84	42	10	58.6	58.0	63.0	74	30	7	4/	4/	4/	4/	4/	4/	57.1	57.0	62.0	63	20	4
NEBRASKA	55.5	55.1	60.3	51	16	3	59.2	58.5	63.3	80	36	9	53.8	53.8	58.6	39	9	2	4/	4/	4/	4/	4/	4/	55.4	55.2	59.8	52	14	2
8 COLORADO	55.4	55.0	60.0	50	13	2	56.5	57.0	61.0	60	18	3	53.9	54.0	59.0	38	9	1	4/	4/	4/	4/	4/	4/	53.4	54.0	59.0	34	8	1
MONTANA	55.7	55.6	61.3	51	17	4	58.8	58.5	64.5	73	34	12	55.4	55.4	61.2	48	16	5	55.3	55.4	60.3	48	14	3	57.5	57.4	63.8	63	29	11
NORTH DAKOTA	54.4	54.5	59.8	51	17	4	58.4	58.3	63.3	75	35	11	56.7	56.8	61.7	64	24	6	3/	3/	3/	3/	3/	3/	56.7	56.7	63.3	61	29	11
SOUTH DAKOTA	53.3	52.2	58.3	30	10	3	57.2	55.0	61.5	57	24	7	59.7	59.1	63.8	78	42	11	3/	3/	3/	3/	3/	3/	56.2	55.4	61.3	54	21	7
UTAH	57.3	57.3	61.8	70	30	4	59.0	59.0	64.5	78	42	15	55.6	56.0	60.0	59	17	1	4/	4/	4/	4/	4/	4/	55.7	55.8	61.6	56	24	8
WYOMING	3/	3/	3/	3/	3/	3/	59.6	59.5	65.2	80	39	16	3/	3/	3/	3/	3/	3/	3/	3/	3/	3/	3/	3/	58.3	58.4	64.8	71	33	14
9 ARIZONA	55.7	55.5	60.0	55	15	3	60.4	59.8	65.8	81	48	18	59.1	58.8	64.3	75	39	13	3/	3/	3/	3/	3/	3/	57.6	57.2	63.7	63	32	12
CALIFORNIA	57.9	57.9	62.5	72	36	8	60.0	59.9	64.8	84	48	16	57.7	57.7	62.7	71	33	9	4/	4/	4/	4/	4/	4/	55.8	55.6	61.6	55	25	9
HAWAII	54.1	53.9	59.6	39	18	3	56.3	56.1	62.4	54	22	6	52.6	52.3	58.8	32	12	4	3/	3/	3/	3/	3/	3/	52.0	51.8	58.5	30	11	4
NEVADA	54.8	55.0	60.0	45	15	4	59.4	59.0	65.0	75	41	14	56.7	57.0	63.0	59	26	7	4/	4/	4/	4/	4/	4/	57.7	58.0	65.0	64	33	13
10 ALASKA	3/	3/	3/	3/	3/	3/	3/	3/	3/	3/	3/	3/	54.5	54.0	58.1	34	4	1	3/	3/	3/	3/	3/	3/	53.2	52.7	58.8	40	15	4
IDAHO	55.0	54.1	59.3	43	8	2	57.7	56.5	62.5	62	22	8	55.6	54.7	60.2	48	12	4	50.9	50.1	55.5	17	2	1	55.0	54.0	59.5	42	10	4
OREGON	57.5	57.5	61.2	67	26	5	56.7	55.6	60.4	61	17	3	55.6	55.8	59.8	52	15	3	4/	4/	4/	4/	4/	4/	54.2	54.3	58.5	39	12	3
WASHINGTON	56.4	56.6	59.0	60	13	1	57.5	57.5	60.0	67	21	4	56.5	56.6	60.0	59	16	2	3/	3/	3/	3/	3/	3/	56.2	56.3	60.0	56	17	3
NATIONAL AVERAGE	56.7	56.5	61.4	60	23	5	58.8	58.6	63.7	74	36	10	56.5	56.4	61.5	59	23	6	54.4	54.7	60.2	44	15	5	54.9	54.8	60.6	48	18	6

1/ MEDIAN SPEED IS THE SPEED AT OR BELOW WHICH 50 PERCENT OF THE VEHICLES ARE TRAVELING.
2/ 85 TH PERCENTILE SPEED IS THE SPEED AT OR BELOW WHICH 85 PERCENT OF THE VEHICLES ARE TRAVELING.
3/ NO MILEAGE IN THIS HIGHWAY CATEGORY WHERE THE 55 MPH SPEED LIMIT IS THE PRIMARY CONSTRAINT ON VEHICLE SPEEDS.
4/ LOW MILEAGE OF MULTI-LANE UNDIVIDED ROADS COMBINED WITH MULTI-LANE DIVIDED ROADS.
5/ MILEAGE REPORTED BUT NO SPEED DATA SUBMITTED.
6/ WILSON BRIDGE ONLY SECTION WITH 55 MPH SPEED LIMIT. MARYLAND MONITORS NEAR BRIDGE.

vehicles in an urban area. Express buses in reserved bus lanes, however, may operate at higher average speeds than the general rush hour traffic. Table 11-3 presents typical bus speeds by road type as reported in the CUTS manual.

MOBILE2 users should consult local transit authority officials or a regional planning agency regarding the distribution of bus miles traveled by roadway type. This distribution is likely to vary among metropolitan areas due to differences in land use characteristics and roadway networks.

Since almost all transit and intercity buses are diesel-powered, average bus speeds should be VMT-weighted with average heavy-duty truck speeds to produce an average for all heavy-duty diesel vehicles. The MOBILE2 user should use the VMT-weighted average speed with MOBILE2 heavy-duty vehicle emission factors to estimate bus and heavy-duty truck emissions using the MOBILE2 model. The following equation describes the VMT-weighted average speed calculation:

$$\left(\frac{VMT_B}{VMT_B + VMT_{HDDT}} \times S_{\bar{B}}\right) + \left(\frac{VMT_{HDDT}}{VMT_B + VMT_{HDDT}} \times S_{\overline{HDDT}}\right) = S_{\bar{H}}, \quad (11\text{-}1)$$

where: VMT_B = total vehicle miles traveled by buses

VMT_{HDDT} = total vehicle miles traveled by heavy-duty diesel trucks

$S_{\bar{B}}$ = average bus speed

$S_{\overline{HDDT}}$ = average heavy-duty diesel truck speed (same as for other non-bus traffic in urban areas)

$S_{\bar{H}}$ = VMT-weighted average speed for all heavy-duty vehicles

11.3 ALL VEHICLES: RURAL SPEEDS

State highway departments collect speed data in a format suitable for compliance with the Surface Transportation Act. The data for each State, disaggregated by highway type, are reported in Table 11-2. A few

TABLE 11-3

TYPICAL BUS SPEEDS

Type of Service	Speed (MPH) Peak	Off-Peak
Local Bus (Small City) on Collector Street	10	12
Local Bus (Large City) on Collector Street	5	7
Local Bus in Bus Lane on Collector Street	8	10*
Local Bus on Arterial Street	10-11	13-15
Local Bus on Arterial Reserved Lane	15	17**
Express Bus on Freeway	30	45
Express Bus in Freeway Bus Lane	45	45+

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* Not usually operated in off-peak hours; estimated at 10 MPH.

** Not usually operated in off-peak hours; estimated at 17 MPH.

+ Not usually operated in off-peak hours; estimated at 45 MPH.

SOURCE: CUTS Manual, 1979.

individual state reports (e.g., those of Michigan and Maryland) disaggregate the data into two categories: passenger vehicles and commercial vehicles.

For the purpose of air quality modeling, it can be assumed that passenger vehicle speeds apply to light-duty cars and trucks (0-6000 lbs. and 6001-8500 lbs. GVW); commercial vehicle speeds apply to all trucks over 8500 lbs. and to all buses. Table 11-4 reports average fleet flow speeds and fractions of total traffic by vehicle type for the State of Michigan. A MOBILE2 user could use the distribution of passenger and commercial vehicles on Michigan highways by roadway type and state-specific average speed data in Table 11-2 to develop average speed by vehicle type and roadway type for other states. Following is a sample calculation of average speeds on rural interstates in Alabama:

Alabama Average Speed on Rural Interstates (all vehicles): 59.9 (Table 11-2)

Michigan Average Speed on Rural Interstates (all vehicles): 58.2 (Table 11-4)

Correction Factor:

Ratio of Alabama to Michigan speeds: 1.029

Michigan average passenger car speed: 58.8 (Table 11-4)
multiply by Correction Factor: x 1.029

Estimated Alabama average passenger car speed: 60.5 MPH

Michigan average commerical vehicle speed: 59.5 (Table 11-4)
multiply by Correction Factor: x 1.029

Estimated Alabama average commercial vehicle speed: 61.2 MPH

TABLE 11-4

AVERAGE FREE FLOW SPEEDS AND FRACTIONS OF TOTAL TRAFFIC ON MICHIGAN HIGHWAYS: PASSENGER AND COMMERCIAL VEHICLES

	Interstate Urban	Interstate Rural	Multi-Lane Divided	Multi-Lane Undivided	2-Lane Rural
Passenger Vehicles					
Average mph	56.5	58.8	57.9	53.1	54.5
% of traffic	88.9	53.8	86.4	97.3	87.5
Commercial Vehicles					
Average mph	53.8	59.5	55.7	49.4	52.9
% of traffic	11.1	46.2	13.6	2.7	12.5
All Vehicles					
Average mph	56.2	58.2	57.6	53.0	54.3
% of Traffic	100.0	100.0	100.0	100.0	100.0

SOURCE: 1979 Annual Speed Report, Michigan Department of Transportation, Bureau of Transportation Planning, Report No. 66.

REFERENCES FOR SECTION 11

DeLeuw, Cather and Co. 1979. Characteristics of Urban Transportation Systems: A Handbook for Transportation Planners. (Prepared for the Urban Mass Transportation Administration, U.S. DOT).

U.S. Department of Commerce. 1950. Highway Capacity Manual. Bureau of Public Roads. Washington, D.C.

Michigan Department of Transportation. 1979. Annual Speed Report. Report No. 66. Bureau of Transportation Planning. Lansing, MI.

12. VEHICLE MILES TRAVELED PER DAY PER VEHICLE

12.1 INTRODUCTION

Mobile source exhaust emissions vary with the total vehicle miles traveled (VMT). Therefore, in order to estimate the evaporative emissions (which are measured in grams per day) from all mobile sources on a common basis with exhaust emissions, the average miles traveled per day per vehicle must be calculated. For all vehicle classifications, the simplest methodology for estimating miles/day in a locality is as follows:

$$\frac{\text{Miles}}{\text{Day}} = \text{Average Trip Length} \times \frac{\text{Trips}}{\text{Day}} \qquad (12\text{-}1)$$

If average trip length is not available, alternate methodologies are presented for estimating the average miles driven per day per vehicle. The methodologies that follow for calculating average miles/day are somewhat different for each vehicle type, and the methodology most suitable for use with locally available data should be employed. It should be stressed, however, that the techniques presented here should be used only if local data for miles/ day are not available. The data sources which were used and the problems associated with calculating miles/day are discussed below. In most cases, the techniques presented here are applicable to urban areas because the trip data used were collected in urban areas.

12.2 LIGHT-DUTY VEHICLES

12.2.1 Data Sources

The data sources employed in calculating miles/day include the Nationwide Personal Transportation Study (hereafter referred to as NPTS), the

1979 Motor Vehicle Manufacturers Association (MVMA) Facts and Figures, and state and local motor vehicle agencies. To obtain VMT, several categories from the NPTS can be utilized, including trip length, trip purpose, household income, and population levels. Depending on the estimation technique utilized, the Census of Population and Housing also can be helpful. Light-duty vehicle (LDV) registration data can be obtained from local motor vehicle agencies. In cases where local registrations are not available, state registration data can be used. State registration data can be obtained from state agencies or the MVMA. Some agencies calculate state and local VMT as well as local trip rates. When available, these data should be used instead of the methodologies presented below.

12.2.2 Methodology

A number of methods can be used to estimate average miles per day driven by light-duty vehicles. Three are presented here. The first methodology is similar to that used in Section 6 to estimate vehicle miles traveled by vehicle type, and can be used if VMT per household is known. This methodology is summarized in equation (12-2):

$$\text{Miles/Day} = \frac{HVMT_L - VT_L - PT_L}{CH_L} \qquad (12\text{-}2)$$

where:

$HVMT_L$ = daily household VMT, for locality L

VT_L = vacation travel per household, for locality L

PT_L = pleasure travel per household, for locality L

CH_L = cars per household, for locality L

Information on daily household VMT by trip purpose and urban area population (see Table 12-1) and the average number of automobiles owned per household (see Table 12-2) can be obtained from the NPTS. Most travel will occur within a particular locality, specifically when related to

TABLE 12-1

AVERAGE ANNUAL AND DAILY PASSENGER CAR VMT PER HOUSEHOLD BY PURPOSE AND POPULATION SIZE*

Purpose	Unincorporated areas		Incorporated places with population of														All Places	
			Under 5,000		5,000-24,999		25,000-49,999		50,000-99,999		100,000-999,999		1,000,000- and over		Total			
	Annual	Daily	Annual	Daily	Annual	Daily	Annual	Daily	Annual	Daily	Annual	Daily	Annual	Daily	Annual	Daily	Annual	Daily
Vacations	345	1.0	432	1.2	265	0.7	57	0.1	314	0.9	193	0.5	554	1.5	295	0.8	320	0.9
Pleasure Travel	384	1.0	428	1.2	377	1.0	538	1.5	159	0.4	357	1.0	453	1.3	379	1.0	381	1.0
All Purposes	15,387	42.1	10,976	30.1	14,696	40.2	11,601	31.8	10,840	29.7	9,399	25.8	8,210	22.5	11,105	30.4	12,423	34.0

* Includes only trip in which a single passenger car or taxi was used.

SOURCE: Based upon unpublished tables T-1.1 and H-18 from the Nationwide Personal Transportation Survey conducted by the Bureau of the Census for the Federal Highway Administration, 1969-70.

TABLE 12-2

AVERAGE NUMBER OF AUTOMOBILES OWNED PER HOUSEHOLD
BY PLACE OF RESIDENCE - IN ALL AREAS AND PLACES

Place of Residence	Average Number of Automobiles per Household
Unincorporated areas	1.3
Incorporated places	
Under 5,000	1.2
5,000-24,999	1.3
25,000-49,999	1.3
50,000-99,999	1.2
100,000-999,999	1.0
1,000,000 and over	0.7
Subtotal	1.1
All areas and places	1.2

SOURCE: U.S. DOT, 1972.

earning a living, family business, and education. Vacation and pleasure travel, however, may not occur with a certain locality. Therefore, VMT estimates for a locality should exclude vacation trips and pleasure travel.

The second suggested methodology for calculating average miles traveled per day for light-duty vehicles is simply based on determining the average LDV trip length and multiplying this number by the average number of LDV trips per day (estimated using the methodologies presented in Section 7 of this report). According to recent MVMA estimates, the average automobile trip length is 8.9 miles. Although this number may change based on the region being analyzed, no procedures are presented here for making more region specific estimates of average trip length. To estimate trips per day, the NPTS presents information organized by both population and annual household income. See Section 7 for more information on trips per day.

The third methodology for estimating LDV average miles per day relies primarily on the annual mileage by model year estimates made using the Section 2 methodologies and the registrations by model year estimates made using the Section 3 methodologies. Using these data, the following steps are followed to estimate miles per day.

- Multiply estimated LDV registrations by model year by the estimated annual mileage by model year and sum to determine the estimated VMT per year by all LDV's.
- Divide the estimated VMT per year by 365 to determine the average daily VMT.
- Divide the average daily VMT estimate by the total number of estimated LDV registrations to obtain a per vehicle miles per day estimate.

12.2.3 Problems Associated with the Methodologies

The average trip length presented in the second methodology is based on the assumption that the households in a locality comprise the total local travel. Such an assumption is not totally realistic. However, the specified average trip length of 8.9 miles (MVMA) is a reasonable estimate for most urban areas. Conceivably, automobile trips outside of one local area by households from that locality counter the effect of households in the second locality traveling outside their area. Thus, the effect of this assumption should be negligible. Also, population characteristics (see Table 12-2) may be difficult to categorize since large urban areas may be composed of both incorporated and unincorporated areas. All of the methods of estimation presented in Section 12.2.2 should not be difficult to apply if the necessary data are available.

12.3 LIGHT-DUTY TRUCKS

Even though there are three classifications of light-duty trucks (LDT), the same methodology can be used to determine miles/day for each. The three vehicle types are: gasoline-powered LDT (1) less than 6000 lbs GVW, gasoline-powered LDT (2) greater than 6000 lbs GVW but less than 8500 lbs GVW, and (3) diesel-powered LDT less than 8500 lbs.

12.3.1 Data Sources

Many of the same data sources used to estimate miles/day for light-duty vehicles are used for estimating miles/day for LDT. The data sources required to determine vehicle miles driven per day for LDT using the methodologies described below are the 1979 MVMA Motor Vehicle Facts and Figures, Census of Population and Housing (1970), The Census of Transportation Truck Inventory and Use (TIU) Survey. If truck registration data are needed they can be obtained from state or local motor vehicle agencies or the MVMA. Information concerning trips/day can be obtained from the MVMA or the U.S. Department of Transportation's Highway Statistics.

Information on truck trip rates may be available from several local or state agencies, such as Councils of Government, Regional Planning Commissions, Transportation Planning Programs, and State Transportation Departments. If light-duty truck miles per day estimates are available locally, they should be used in preference to the techniques presented here. However, users should be aware that many transportation agencies classify trucks differently than the truck categories used in MOBILE2. Care should be taken in matching these categories correctly.

12.3.2 Methodology

Two methodologies are presented here for estimating average miles per day driven by light-duty trucks. The first uses estimated light-duty truck registrations and average mileage accumulation by age information to compute an average VMT per year number. After this number is converted to VMT per day, it is divided by the total number of registered vehicles to derive a per vehicle estimate. Annual mileage by model year estimates for light-duty trucks can be based either on locally available data or developed using the Section 2 methodologies. Likewise, registrations by model year estimates can be based on locally available data or developed using the Section 3 methodologies.

The second methodology for calculating miles per day is based on the technique used in Section 6 and estimates miles per day by using state and local urban truck VMT, and the portion of total urban truck travel accounted for by a given truck type (Table 6-5). Urban truck travel is based on the assumption that truck travel accounts for 18.66 percent of total urban travel. According to MVMA, in 1977, trucks traveled 153,350 out of a total of 821,971 million urban miles (Table 6-4). Urban truck travel for each state also can be obtained from the TIU Survey.

In order to calculate local truck VMT, one of two apportioning factors must be used. These are based on the assumption that the number of

trucks per person is the same for a State as the locality within that State. The first apportioning factor utilizes both local and State registration data. This factor is defined as the ratio of total LDT registration in locality (L) to total LDT registration in State (S). Assuming that statewide urban travel per truck is equal to local urban travel per truck, the ratio of local urban truck miles traveled to State urban truck miles traveled should be equal to the ratio of trucks registered in a local area to trucks registered in the State. The second apportioning factor is based on population data from the Census Bureau, and follows the same assumption that the ratio of local population to State population is equal to the ratio of local trucks registered to State trucks registered.

The final equation can utilize either one of these apportioning factors from Section 6.2.2. The one to be used depends on whether local VMT or population data are available.

$$\text{Annual VMT} = TVMT_S \times \text{Apportioning Factor} \times \%\ UT_T \qquad (12\text{-}3)$$

where $TVMT_S$ = Urban truck travel in State (S)

$\%\ UT_T$ = Portion truck type (T) of total urban truck VMT

12.3.3 Problems Associated with the Methodologies

Most of the problems associated with the second methodology for light-duty trucks are associated with the apportioning factors. These problems are discussed fully in Section 7.2.1.3.

12.4 HEAVY-DUTY TRUCKS

Heavy-duty trucks (HDT) are defined as being greater than 8500 lbs and can be either gasoline-powered or diesel-powered. The methodology for determining the number of miles/day is the same for both types.

12.4.1 Data Sources

The data sources used for estimating VMT for HDT are the same as those used for LDT. They are the 1979 (MVMA) Motor Vehicle Facts and Figures, The Census of Transportation Truck Inventory and Use (TIU) Survey, the Department of Transportation's Highway Statistics (U.S. DOT, 1978), and State and local registration data.

12.4.2 Methodology

The number of miles driven per day can be estimated separately for heavy-duty gasoline and diesel trucks using estimated registration and average mileage accumulation by age information for each vehicle type. Locally available data should be used where possible for both of these variables. If needed, the methodologies presented in Section 2 and 3 of this report can be used to estimate mileage accumulation by age and vehicle registrations by age, respectively. Using these data, the following steps are followed to estimate miles per day:

- Multiply estimated HDGV (HDDV) registrations by model year by the estimated annual mileage by model year and sum to determine the estimated VMT per year by all HDGV's (HDDV's).
- Divide the estimated VMT per year by 365 to determine the average daily VMT.
- Divide the average daily VMT estimate by the total number of estimated HDGV (HDDV) registrations to obtain a per vehicle miles per day estimate.

12.4.3 Problems Associated with the Methodologies

Problems which may occur with the VMT methodologies are basically the same as those which occur in the light-duty truck analysis. These problems are discussed in Section 12.3.3.

12.5 MOTORCYCLES

12.5.1 Data Sources

The main data sources for estimating miles per day for motorcycles are the Motorcycle Statistical Annual (MSA) and Survey of Motorcycle Ownership, Usage, and Maintenance, both by the Motorcycle Industry Council (MIC). Before the methodologies described below are utilized, state and local agencies and the Motorcycle Industry Council should be contacted for specific information.

12.5.2 Methodology

The method presented here for estimating average miles driven per day by motorcycles is similar to that presented for all other vehicle types where registrations and average mileage accumulation by age information are used to compute an average VMT per year number. The difference here is that motorcycles are assumed to travel less than 365 days per year. (See Table 2-7 for average driving season lengths by U.S. region.) Therefore, VMT per year for motorcycles is converted to VMT per day by dividing by the number of days in an average driving season in the area being analyzed. Then, VMT per day is divided by the total number of registered motorcycles to derive a per vehicle estimate.

12.5.3 Problems Associated with Methodology

The problems associated with the methodology presented here for estimating average miles per day driven by motorcycles are the same are those for the other vehicle types. There are discussed fully in Section 12.2.3.

REFERENCES FOR SECTION 12

Motorcycle Industry Council, Inc. 1979. Motorcycle Statistical Annual. Newport Beach, CA.

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Census of Transportation. 1977. Truck Inventory and Use Survey.

13. AIR CONDITIONING USAGE

MOBILE2 contains a correction factor for air conditioning usage which accounts for an increase in certain emissions when vehicle air conditioners are in use. This section presents techniques for estimating the total number of light-duty vehicles and trucks equipped with air conditioning units and the ambient conditions which influence their frequency of operation.

13.1 LIGHT-DUTY VEHICLES AND LIGHT-DUTY TRUCKS

The following subsections provide a method by which the total number of LDV and LDT air conditioner sales may be estimated and the effects ambient conditions may have on their frequency of operation. This method applies to both gasoline and diesel-powered vehicles.

13.1.1 Data Sources

The information in this section should be used in conjunction with the information in Section 9 of this report to estimate air conditioning usage. Techniques for estimating the number of vehicles with air conditioning units for light-duty vehicles and light-duty trucks are presented in Section 9.

Various publications supply climatic data for the major metropolitan areas of the U.S. This information may be found in the Smithsonian Meteorological Tables, abstracts from the National Climatic Center in Asheville, N.C., some local Weather Bureau offices, and various handbooks on air conditioning, heating, and ventilation. All of these sources provide the temperature-humidity index (THI), or discomfort index, which provides a good indication of the perceived need for cooling. These data are available for most cities throughout the country.

Additional sources of data that would support the relative need for air conditioning are those that concern the Pollutant Standard Index (PSI). The Tenth Annual Report of the Council on Environmental Quality December 1979 provides a ranking of Standard Metropolitan Statistical Areas (SMSA's) according to PSI data collected during the years 1975 through 1977. Air conditioning usage should increase in those areas with relatively higher pollution levels.

Other sources of data suggesting relative need for automotive air conditioning are those that detail the existence of ragweed and other sources of airborne pollens throughout the U.S. The data compiled by Oren C. Durham for the American Academy of Allergy, entitled Hay Fever Holiday, published by and available from, Abbott Laboratories, Chicago, Illinois, presents lists and maps showing relative concentrations of airborne pollens for all parts of the country. This information may aid in assessing the regional need for automotive air conditioning usage.

13.1.2 Estimation Techniques

The percentage of domestic and imported U.S. cars and trucks with factory-installed air conditioners by model year can be estimated using the techniques presented in Section 9. Methods for estimating the frequency of use of these air conditioners are presented in the following three subsections. While it is thought that temperature and humidity, air pollution levels, and airborne pollens all influence air conditioner use, only the relationship between temperature and humidity and air conditioner use has been quantified. Therefore, the MOBILE2 user can use any, or all, of the following information to estimate air conditioner usage in their particular area.

13.1.2.1 Temperature and Humidity

The most significant factor influencing frequency of air conditioning usage is the temperature-humidity index (THI), sometimes referred to as

the discomfort index (DI). This equation, derived by J.F. Bosen, Office of Climatology, U.S. Weather Bureau, is:

$$DI = 0.4\ (t_d + t_w) + 15 \qquad (13\text{-}1)$$

where, DI = Discomfort Index

t_d = Dry bulb temperature*

t_w = Wet bulb temperature**

(the temperatures are simultaneous readings). The DI is not a temperature reading but a unitless measure reflecting the degree of discomfort due to temperature and humidity. The higher the value, the greater the degree of discomfort. Though it is difficult to quantify degree of discomfort, researchers have found that at a DI of 70 or below, almost everyone is comfortable; at 72, about 20 percent of the population feels uncomfortable; at 75, about 50 percent feels uncomfortable; and at a DI of 80, almost 100 percent feel uncomfortable. Thus, one may expect that the use air conditioners would be higher as the DI becomes higher.

Values for the dry and wet bulb temperatures can be obtained from the local National Weather Service station. See the discussion in Section 4 and Figure 4-1 for more information. Care should be taken so that the temperature values used are from the period for which the emission inventory is being compiled.

Other factors, such as effects of solar radiation through the vehicle's windows and surface wind speed (due primarily to the motion of the vehicle) influence the vehicle's "microclimate." Although these factors are significant, they work in opposition and may have a cancelling

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* The temperature of air measured by a conventional thermometer.

** The temperature of the air as measured by a wet-bulb thermometer, and which is lower than the dry bulb thermometer in inverse proportion to the humidity (for all cases except when the air is saturated).

effect on each other and, hence, on the decision to initiate air conditioning. Once the decision to use air conditioning is made, however, both the number of clear days and intensity of solar radiation entering and subsequently absorbed by the vehicle have a profound effect on how long the air conditioner remains on. Table 13-1 presents U.S. monthly mean values for dry and wet bulb temperature with the appropriate discomfort index and AC usage calculated for each month as an example of how equation (13-1) can be applied to estimate AC usage. Table 13-2 presents the average monthly DI for selected metropolitan areas. Twelve regions of the country during the warmest months of the year are represented.

13.1.2.2 Smog and Air Pollution

The presence of various pollutants should influence frequency of air conditioner use. Assuming all other factors contributing to the use of air conditioning in motor vehicles are held constant, an increase in one or more of the "criteria pollutants" would tend to increase the need for air conditioning. These pollutants are monitored on a daily basis in every metropolitan area. The Tenth Annual Report of the Council on Environmental Quality - December 1979 lists a ranking of SMSA's according to the number of days ambient pollutant standard index (PSI) readings were above values of 100 and 200. EPA adopted the PSI, a health-related index designed to be reported by the news media, so that susceptible persons can gain knowledge of and respond appropriately to changes in air pollution levels. The PSI makes it possible to compare air pollution levels on a uniform basis throughout the nation. The PSI is based generally on the primary short-term NAAQS and Federal criteria for categorizing more severe pollution episodes. A PSI value greater than 100 means that the air quality is categorized as "unhealthful," greater than 200 as "very unhealthful," and greater than 300 as "hazardous." More exact definitions of these index values are presented in Table 13-3. Ranking of SMSA's is presented in Table 13-4.

13.1.2.3 Airborne Pollens and Allergy

The presence, or absence, of certain airborne pollens during the summer season can have a significant effect on automotive air conditioning usage. In areas of particularly heavy concentrations of ragweed pollen, for example, a hay fever sufferer can travel in a car only with the windows closed and air conditioner in operation. Although pollen count data are available for almost every city in the U.S., it would not be useful for this type of analysis. Rather, a listing of the relative pollen concentrations, or a map providing similar information, may be helpful in determining general relationships and tendencies for relative frequency of air conditioner use. Figure 13-1 provide a general overview of regions in the U.S. showing relative concentrations of airborne ragweed pollen that may correlate with higher frequency of air conditioner use in light-duty autos and trucks.

13.2 USEFULNESS OF DATA

Although the previous sections have identified the main determinants for air conditioning usage in light-duty vehicles, there exists no simple or quantifiable algorithm into which all these data may be placed. As was previously stated, the data are useful for comparing climatic characteristics of cities representing major geographical regions of the U.S. Certainly the recent price gains and regional price variations in gasoline would tend to confound any estimate of air conditioning usage assuming everything else remains constant.

The DI is based on an actual poll of individuals and is, therefore, a fairly reliable indicator (over a one month averaging period) of the percentage of people likely to use air conditioning. The PSI and airborne pollen parameters, though definitely contributing to overall AC use, should not be used as independent data sources and should be used only in conjunction with the DI values. Because temperature and humidity

are more directly related to air conditioner use than air pollution levels or pollen count, it is recommended that the DI equation (13-1) be used to estimate the percentage of light-duty vehicles and trucks using their air conditioner. No attempt is made, at this time, to ascribe an importance value or estimate the degree of influence the PSI and pollen concentration factors exert on the DI. The PSI and DI values, however, are presented together in Table 13-2 to illustrate possible synergistic tendencies - the increase in probability of air conditioner use in those areas where both values appear in the upper limits of their respective range.

TABLE 13-1

AMBIENT CONDITIONS LIKELY TO AFFECT VEHICLE AIR CONDITIONING USAGE

WET BULB TEMPERATURES CORRESPONDING TO MONTHLY
MEAN DRY BULB TEMPERATURES AND MEAN RELATIVE HUMIDITIES
FOR THE UNITED STATES

	Mean Dry Bulb (°F)*	Mean Reative Humidity (%)*	H(grains of water vapor/pound of dry air)**	Mean Wet Bulb (°F)†	Disconfort Index	AC Usage
January	45	67	31	40	49	0
February	49	64	36	43	52	0
March	55	65	41	49	57	0
April	65	69	63	59	65	0
May	72	72	91	66	70	0
June	81	67	112	73	77	70%
July	85	62	121	75	79	90%
August	85	62	121	75	79	90%
September	78	71	99	71	75	50
October	68	68	71	61	67	0
November	56	67	44	50	62	0
December	48	68	33	43	51	0

* Source: Climatography of the United States Series 82

** To two significant places

† Source: Handbook of Chemistry and Physics

TABLE 13-2

TEMPERATURE-HUMIDITY INDEX (THI)/POLLUTANT STANDARD INDEX (PSI)
BY REGION

Region	Month	Temperatures				THI	Number of "Unhealthful" Days (PSI over 100) 3 year average 1975-77
		Average		Extreme			
		Min	Max	Min	Max		
NORTHEAST							
Connecticut							
Hartford	June	57	81	38	100	75	34
	July	62	86	48	101	78	
	Aug	60	83	38	101	76	
	Sept	52	76	30	101	72	
Maine							
Portland	July	57	79	41	98	74	78
	Aug	55	77	38	100	73	
Massachusetts							
Boston	June	59	76	46	94	72	
	July	65	82	54	98	74	
	Aug	63	80	47	93	74	
Nantucket	July	62	74	50	90	71	
	Aug	62	74	46	86	72	
New Hampshire							
Concord	June	50	78	32	101	72	
	July	55	83	38	102	76	
	Aug	53	80	33	100	74	
New Jersey							
Atlantic City	June	61	79	39	96	72	
	July	66	84	46	104	76	
	Aug	65	82	40	95	76	
	Sept	58	76	35	92	71	
Newark	June	61	81	43	102	75	74[b]
	July	67	86	52	105	78	
	Aug	65	84	51	103	77	
	Sept	58	77	35	105	72	
New York							
Albany	June	55	79	33	99	73	
	July	60	83	44	100	76	
	Aug	58	81	35	99	75	
New York	June	62	78	44	97	73	273[b]
	July	67	82	54	102	76	
	Aug	66	80	51	102	75	
	Sept	60	75	39	100	71	
Pennsylvania							
Philadelphia	June	62	83	44	100	77	103
	July	66	87	52	102	79	
	Aug	64	84	50	101	77	
	Sept	58	78	36	100	73	

TABLE 13-2 (cont'd)

TEMPERATURE-HUMIDITY INDEX (THI)/POLLUTANT STANDARD INDEX (PSI)
BY REGION

Region	Month	Temperatures				THI	Number of "Unhealthful" Days (PSI over 100) 3 year average 1975-77
		Average		Extreme			
		Min	Max	Min	Max		
NORTHEAST (cont'd)							
Rhode Island							
Providence	June	56	75	39	101	70	
	July	62	80	49	101	75	
	Aug	60	79	44	102	74	
Vermont							
Burlington	June	54	78	33	96	72	
	July	58	82	43	100	76	
	Aug	56	80	38	101	74	
MID-ATLANTIC							
Delaware							
Wilmington	May	51	75	34	93	70	
	June	60	83	45	99	77	
	July	65	87	50	102	79	
	Aug	63	85	48	101	79	
	Sept	57	79	37	100	74	
Washington, D.C.	May	56	76	36	96	69	110
	June	65	83	47	100	77	
	July	69	87	56	101	78	
	Aug	68	85	51	99	77	
	Sept	61	79	39	95	73	
Kentucky							
Louisville	May	54	77	33	98	72	150
	June	63	85	43	103	78	
	July	67	89	49	107	81	
	Aug	65	88	45	105	80	
	Sept	58	82	33	104	75	
Maryland							
Baltimore	June	61	[illegible]	42	100	77	64[a]
	July	66	87	52	102	79	
	Aug	65	85	48	102	79	
	Sept	58	79	35	99	74	
North Carolina							
Asheville	May	50	76	30	91	69	
	June	58	82	35	96	75	
	July	61	84	46	94	78	
	Aug	61	83	43	94	77	
	Sept	54	78	30	85	74	
Charlotte	May	59	79	32	95	74	
	June	67	88	46	99	80	
	July	70	89	53	99	81	
	Aug	70	88	53	100	80	
	Sept	64	82	39	94	77	
Raleigh	May	56	80	33	92	73	
	June	64	86	43	95	79	
	July	68	88	55	97	81	
	Aug	67	87	46	98	81	
	Sept	60	82	42	92	78	

TABLE 13-2 (cont'd)

TEMPERATURE-HUMIDITY INDEX (THI)/POLLUTANT STANDARD INDEX (PSI)
BY REGION

Region	Month	Temperatures				THI	Number of "Unhealthful" Days (PSI over 100) 3 year average 1975-77
		Average		Extreme			
		Min	Max	Min	Max		
MID-ATLANTIC (cont'd)							
North Carolina (cont'd)							
Wilmington	May	60	81	43	97	76	
	June	68	87	50	100	80	
	July	71	89	60	99	82	
	Aug	71	88	57	100	81	
	Sept	66	84	48	95	79	
South Carolina							
Charleston	April	53	77	29	93	70	
	May	62	84	36	98	77	
	June	69	89	51	103	81	
	July	72	89	58	101	83	
	Aug	71	89	58	102	82	
	Sept	66	85	42	99	80	
	Oct	55	77	27	94	72	
Columbia	April	51	76	34	92	69	
	May	60	85	39	93	76	
	June	68	92	52	100	82	
	July	71	93	59	99	83	
	Aug	70	91	53	106	81	
	Sept	65	86	40	93	80	
	Oct	52	77	29	89	71	
Greenville	May	59	79	38	97	73	
	June	68	86	46	98	79	
	July	71	87	58	98	80	
	Aug	70	86	52	99	78	
	Sept	64	81	36	91	76	
Tennessee							
Knoxville	May	56	79	34	96	73	
	June	65	87	42	102	79	
	July	68	89	52	104	81	
	Aug	66	88	49	102	80	
	Sept	61	84	35	103	77	
Memphis	May	60	80	38	98	75	24
	June	68	88	50	104	80	
	July	71	91	52	106	83	
	Aug	70	90	48	105	83	
	Sept	63	85	36	103	78	
	Oct	52	76	25	95	70	
Nashville	May	57	79	36	96	73	59
	June	66	88	42	106	80	
	July	69	91	51	107	83	
	Aug	68	89	47	105	81	
	Sept	62	85	36	105	78	
	Oct	50	74	26	94	68	
Virginia							
Norfolk	May	58	76	33	98	70	13
	June	66	83	49	102	77	
	July	71	87	57	104	79	
	Aug	70	85	56	105	79	
	Sept	65	80	40	100	75	

TABLE 13-2 (cont'd)

TEMPERATURE-HUMIDITY INDEX (THI)/POLLUTANT STANDARD INDEX (PSI)
BY REGION

Region	Month	Temperatures				THI	Number of "Unhealthful" Days (PSI over 100) 3 year average 1975-77
		Average		Extreme			
		Min	Max	Min	Max		
MID-ATLANTIC (cont'd)							
Virginia (cont'd)							
Richmond	May	55	77	35	98	72	
	June	64	84	43	104	77	
	July	68	88	52	105	80	
	Aug	67	86	49	107	79	
	Sept	61	81	40	101	76	
GULF							
Alabama							
Mobile	April	57	76	36	92	71	
	May	64	83	45	100	77	
	June	71	89	56	102	81	
	July	72	89	60	104	82	
	Aug	72	90	59	102	83	
	Sept	69	87	47	98	80	
	Oct	59	79	32	93	73	
Montgomery	April	53	77	30	92	73	
	May	61	84	43	99	77	
	June	69	91	48	106	83	
	July	71	91	61	107	83	
	Aug	71	91	58	104	83	
	Sept	66	88	45	106	80	
	Oct	54	79	26	100	73	
Florida							
Tallahassee	April	56	79	32	92	74	
	May	63	86	43	102	78	
	June	70	91	56	103	83	
	July	72	91	62	100	84	
	Aug	72	90	63	99	83	
	Sept	69	87	50	98	81	
	Oct	59	81	33	94	74	
Louisiana							
New Orleans	April	62	78	38	91	73	
	May	68	84	50	97	78	
	June	74	89	58	102	82	
	July	76	90	66	102	83	
	Aug	76	91	63	100	84	
	Sept	73	87	54	99	81	
	Oct	65	80	40	94	75	
Texas							
Brownsville	Feb	55	73	32	85	70	
	March	59	77	35	87	73	
	April	66	82	51	93	77	
	May	71	87	53	99	80	
	June	75	91	66	95	83	
	July	76	93	70	96	84	
	Aug	75	93	63	96	84	
	Sept	73	90	56	93	83	
	Oct	67	85	52	91	80	
	Nov	58	77	41	88	73	

TABLE 13-2 (cont'd)

TEMPERATURE-HUMIDITY INDEX (THI)/POLLUTANT STANDARD INDEX (PSI)
BY REGION

Region	Month	Temperatures				THI	Number of "Unhealthful" Days (PSI over 100) 3 year average 1975-77
		Average		Extreme			
		Min	Max	Min	Max		
GULF (cont'd)							
Texas (cont'd)							
Houston	April	59	78	38	93	73	54
	May	66	86	52	94	78	
	June	72	91	59	100	82	
	July	74	92	64	101	84	
	Aug	74	93	64	106	85	
	Sept	69	89	50	98	82	
	Oct	60	82	38	96	76	
FLORIDA							
Jacksonville	April	58	80	35	93	73	
	May	65	86	49	99	77	
	June	71	91	57	103	82	
	July	73	92	65	105	83	
	Aug	73	91	64	102	83	
	Sept	71	88	55	100	81	
	Oct	62	80	38	96	75	
Key West	Jan	65	74	49	85	72	
	Feb	66	75	47	85	74	
	March	68	77	55	87	75	
	April	72	80	55	88	77	
	May	75	83	66	91	80	
	June	78	86	68	94	82	
	July	79	87	69	95	83	
	Aug	79	88	68	95	83	
	Sept	78	87	70	94	82	
	Oct	75	83	60	92	79	
	Nov	71	78	49	88	75	
	Dec	67	75	46	85	73	
Miami	Jan	58	76	34	87	73	
	Feb	59	77	32	89	74	
	March	61	80	40	90	76	
	April	66	83	41	93	78	
	May	70	85	53	94	80	
	June	74	88	65	98	83	
	July	75	89	69	96	84	
	Aug	75	90	68	98	84	
	Sept	75	88	69	95	83	
	Oct	71	85	51	92	80	
	Nov	65	80	39	89	76	
	Dec	59	77	35	86	74	
Orlando	Feb	51	72	41	88	70	
	March	54	76	40	90	72	
	April	60	81	47	94	76	
	May	66	86	52	96	79	
	June	71	89	62	98	83	
	July	73	90	69	100	84	
	Aug	74	90	67	99	84	
	Sept	72	88	68	95	83	
	Oct	65	83	49	91	79	
	Nov	56	76	49	88	73	
	Dec	51	72	29	90	69	

TABLE 13-2 (cont'd)

TEMPERATURE-HUMIDITY INDEX (THI)/POLLUTANT STANDARD INDEX (PSI)
BY REGION

Region	Month	Temperatures				THI	Number of "Unhealthful" Days (PSI over 100) 3 year average 1975-77
		Average		Extreme			
		Min	Max	Min	Max		
FLORIDA (cont'd)							
Tampa	March	56	76	34	91	71	11
	April	61	81	42	93	75	
	May	67	87	54	96	78	
	June	72	89	62	98	81	
	July	73	90	64	97	83	
	Aug	74	90	67	97	83	
	Sept	72	89	59	96	83	
	Oct	66	84	42	94	77	
	Nov	57	77	29	90	71	
GREAT LAKES							
Illinois							
Chicago	June	62	80	45	96	74	139
	July	67	84	50	98	78	
	Aug	66	82	43	98	77	
	Sept	57	75	40	94	71	
Springfield	June	63	85	40	99	77	
	July	66	90	48	106	79	
	Aug	64	87	43	103	77	
	Sept	55	80	35	99	72	
Indiana							
Indianapolis	June	60	83	39	102	77	33[a]
	July	64	88	44	104	80	
	Aug	63	86	42	100	78	
	Sept	56	79	28	100	73	
Michigan							
Detroit	June	60	79	38	104	73	
	July	65	84	47	105	77	
	Aug	64	82	43	100	75	
Flint	June	55	79	40	94	73	
	July	59	84	40	94	76	
	Aug	58	82	39	97	74	
Grand Rapids	June	56	79	37	94	73	3[a]
	July	60	85	47	97	77	
	Aug	58	83	41	100	75	
New York							
Buffalo	June	55	76	35	97	71	41
	July	60	81	43	96	75	
	Aug	59	79	43	99	73	
Syracuse	June	56	79	34	100	73	6
	July	61	84	44	102	77	
	Aug	60	81	42	98	75	
	Sept	53	74	25	97	69	

TABLE 13-2 (cont'd)

TEMPERATURE-HUMIDITY INDEX (THI)/POLLUTANT STANDARD INDEX (PSI)
BY REGION

Region	Month	Temperatures				THI	Number of "Unhealthful" Days (PSI over 100) 3 year average 1975-77
		Average		Extreme			
		Min	Max	Min	Max		
GREAT LAKES (cont'd)							
Ohio							
Cincinnati	May	53	74	32	95	69	41
	June	62	83	40	102	77	
	July	66	87	50	109	79	
	Aug	64	85	43	103	78	
	Sept	58	80	32	101	74	
Cleveland	May	48	70	29	92	70	225[a]
	June	58	80	38	101	74	
	July	63	85	46	103	78	
	Aug	61	83	44	102	77	
	Sept	55	76	32	101	71	
Columbus	May	49	73	28	96	68	
	June	59	82	39	102	76	
	July	63	86	44	106	78	
	Aug	61	84	42	103	77	
	Sept	55	78	31	100	72	
Pennsylvania							
Erie	June	55	76	40	97	73	
	July	60	81	47	98	76	
	Aug	59	79	42	96	75	
	Sept	54	73	33	99	69	
Pittsburgh	June	58	79	43	94	73	
	July	62	83	49	99	77	
	Aug	59	81	46	97	75	
	Sept	55	75	34	97	69	
West Virginia							
Charleston	May	50	77	31	98	71	
	June	60	85	39	105	78	
	July	64	87	46	108	81	
	Aug	62	86	47	108	79	
	Sept	56	81	33	104	75	
Wisconsin							
Madison	June	56	79	33	97	73	
	July	60	86	42	102	79	
	Aug	58	83	39	101	77	
	Sept	51	74	25	99	69	
Milwaukee	June	55	75	33	99	71	35
	July	61	81	45	101	75	
	Aug	61	79	44	100	75	
NORTH CENTRAL							
Iowa							
Des Moines	June	61	81	45	96	75	
	July	65	87	53	100	79	
	Aug	63	85	48	100	78	
	Sept	54	77	32	93	71	

TABLE 13-2 (cont'd)

TEMPERATURE-HUMIDITY INDEX (THI)/POLLUTANT STANDARD INDEX (PSI)
BY REGION

Region	Month	Temperatures				THI	Number of "Unhealthful" Days (PSI over 100) 3 year average 1975-77
		Average		Extreme			
		Min	Max	Min	Max		
NORTH CENTRAL (cont'd)							
Minnesota							
Duluth	July	56	77	40	97	73	
	Aug	55	75	37	97	71	
Minneapolis	June	58	79	32	100	74	
	July	63	85	48	104	77	
	Aug	61	82	40	102	76	
Nebraska							
Omaha	June	62	83	39	105	77	
	July	68	89	51	114	81	
	Aug	65	86	43	110	79	
	Sept	56	78	30	104	72	
North Dakota							
Fargo	June	53	77	33	99	72	
	July	58	84	40	101	77	
	Aug	56	82	37	105	76	
South Dakota							
Rapid City	June	52	76	31	101	70	
	July	59	86	40	109	77	
	Aug	57	85	40	106	76	
CENTRAL							
Arkansas							
Little Rock	May	60	82	40	98	76	
	June	68	90	49	102	82	
	July	71	93	56	105	84	
	Aug	70	93	52	108	83	
	Sept	62	86	38	102	78	
	Oct	50	76	31	97	72	
Kansas							
Wichita	May	55	75	33	99	70	
	June	65	86	44	106	78	
	July	69	92	59	113	82	
	Aug	68	92	48	107	82	
	Sept	61	83	43	103	76	
Missouri							
Kansas City	May	56	75	34	94	70	12
	June	67	85	47	99	77	
	July	71	92	54	104	82	
	Aug	69	90	50	104	81	
	Sept	60	83	40	97	74	
St. Louis	May	53	75	31	92	70	123
	June	63	85	46	96	77	
	July	67	89	51	106	81	
	Aug	66	87	47	105	80	
	Sept	58	81	40	96	74	

TABLE 13-2 (cont'd)

TEMPERATURE-HUMIDITY INDEX (THI)/POLLUTANT STANDARD INDEX (PSI)
BY REGION

Region	Month	Temperatures				THI	Number of "Unhealthful" Days (PSI over 100) 3 year average 1975-77
		Average		Extreme			
		Min	Max	Min	Max		
CENTRAL							
Oklahoma							
Oklahoma City	May	59	78	40	96	75	11[b]
	June	69	87	52	98	81	
	July	72	93	59	108	84	
	Aug	72	94	54	105	83	
	Sept	63	85	41	93	78	
	Oct	52	74	32	89	69	
Texas							
Dallas	April	55	75	33	99	72	26
	May	63	83	42	98	77	
	June	72	91	53	102	83	
	July	75	95	65	105	85	
	Aug	75	95	61	107	85	
	Sept	67	88	46	103	80	
	Oct	57	79	38	94	74	
ROCKY MOUNTAIN							
Colorado							
Denver	June	51	82	40	96	73	157
	July	57	88	48	99	76	
	Aug	56	87	41	100	75	
	Sept	47	79	29	97	68	
Idaho							
Boise	June	51	78	34	109	72	
	July	59	91	41	106	80	
	Aug	57	88	41	105	77	
	Sept	48	77	27	102	70	
Montana							
Billings	June	52	77	32	102	71	
	July	59	88	42	106	78	
	Aug	56	86	40	104	77	
Wyoming							
Cheyenne	July	54	83	38	100	73	
	Aug	53	81	37	96	73	
NEVADA AND UTAH							
Nevada							
Las Vegas	May	60	88	38	109	70	
	June	68	99	48	116	79	
	July	76	105	56	117	84	
	Aug	74	103	54	116	83	
	Sept	65	96	43	113	78	
Reno	June	42	81	25	100	71	
	July	47	92	35	104	77	
	Aug	45	90	32	102	76	
	Sept	39	82	21	101	71	

TABLE 13-2 (cont'd)

TEMPERATURE-HUMIDITY INDEX (THI)/POLLUTANT STANDARD INDEX (PSI)
BY REGION

Region	Month	Temperatures				THI	Number of "Unhealthful" Days (PSI over 100) 3 year average 1975-77
		Average		Extreme			
		Min	Max	Min	Max		
NEVADA AND UTAH (cont'd)							
Utah							
Salt Lake City	June	52	82	35	103	73	82
	July	61	92	41	106	79	
	Aug	59	90	31	103	77	
	Sept	49	79	30	98	70	
SOUTHWEST							
Arizona							
Phoenix	April	50	84	32	104	73	
	May	58	95	42	113	77	
	June	66	102	50	117	84	
	July	75	105	61	118	88	
	Aug	74	102	60	115	87	
	Sept	67	98	49	118	79	
	Oct	54	88	36	104	77	
Tucson	April	50	81	27	102	71	
	May	57	89	38	107	79	
	June	66	98	47	111	81	
	July	73	99	63	111	85	
	Aug	72	96	61	109	83	
	Sept	67	93	48	107	80	
	Oct	55	84	35	101	74	
New Mexico							
Albuquerque	May	52	79	34	98	70	
	June	61	89	45	101	76	
	July	66	92	55	104	80	
	Aug	65	89	53	100	78	
	Sept	58	82	39	98	73	
Texas							
Amarillo	May	53	80	33	99	72	
	June	63	91	43	104	79	
	July	67	94	55	102	81	
	Aug	66	93	52	104	80	
	Sept	58	85	39	98	75	
El Paso	May	57	87	31	100	72	
	June	67	95	51	106	83	
	July	69	95	64	106	82	
	Aug	68	93	58	102	81	
	Sept	61	88	45	98	77	
	Oct	50	79	27	92	70	

TABLE 13-2 (cont'd)

TEMPERATURE-HUMIDITY INDEX (THI)/POLLUTANT STANDARD INDEX (PSI)
BY REGION

Region	Month	Temperatures				THI	Number of "Unhealthful" Days (PSI over 100) 3 year average 1975-77
		Average		Extreme			
		Min	Max	Min	Max		
PACIFIC NORTHWEST							
Oregon							
Pendleton	June	53	79	36	108	70	
	July	58	89	42	110	76	
	Aug	57	87	41	113	75	
	Sept	50	78	30	102	68	
Portland	July	56	79	43	107	73	
	Aug	55	78	44	100	73	
Washington							
Seattle	July	56	75	48	100	69	86
	Aug	56	74	48	97	68	
Spokane	July	55	86	39	102	72	
	Aug	53	83	35	108	72	
CALIFORNIA							
Bakersfield	April	50	76	38	98	68	
	May	56	85	41	102	74	
	June	62	92	48	111	79	
	July	68	100	59	110	87	
	Aug	66	98	57	111	84	
	Sept	61	92	50	108	79	
	Oct	53	81	45	97	74	
Los Angeles	May	56	74	46	102	69	264
	June	59	77	50	104	72	
	July	63	83	54	103	77	
	Aug	63	83	53	103	77	
	Sept	61	83	51	110	76	
	Oct	57	77	46	104	72	
Sacramento	May	50	78	37	101	71	26
	June	54	87	43	115	75	
	July	57	93	50	113	79	
	Aug	56	92	49	107	78	
	Sept	55	88	43	104	75	
	Oct	49	78	38	99	69	
San Diego	July	63	77	57	88	72	59
	Aug	66	78	60	89	73	
	Sept	62	78	56	111	72	
San Francisco							33

TABLE 13-3

DEFINITION OF POLLUTANT STANDARD INDEX (PSI) VALUES

PSI Index Value	Air Quality Level	Pollutant Level					Health Effect	General Health Effects	Cautionary Statements
		TSP (24-hour) ug/m^3	SO_2 (24-hour) ug/m^3	CO (8-hour) mg/m^3	O_3 (1-hour) ug/m^3	NO_2 (1-hour) ug/m^3			
500	Significant Harm	1000	2620	57.5	1200	3750			
400	Emergency	875	2100	46.0	1000	3000		Premature death of ill and elderly. Healthy people will experience adverse symptoms that affect their normal activity.	All persons should remain indoors, keeping windows and doors closed. All persons should minimize physical exertion and avoid traffic.
300	Warning	625	1600	34.0	800	2260	Hazardous	Premature onset of certain diseases in addition to significant aggravation of symptoms and decreased exercise tolerance in healthy persons.	Elderly and persons with existing diseases should stay indoors and avoid physical exertion. General population should avoid outdoor activity.
200	Alert	375	800	17.0	400[c]	1130	Very Unhealthful	Significant aggravation of symptoms and decreased exercise tolerance in persons with heart or lung disease, with widespread symptoms in the healthy population.	Elderly and persons with existing heart or lung disease should stay indoors and reduce physical activity.
100	NAAQS	260	365	10.0	240		Unhealthful[a]	Mild aggravation of symptoms in susceptible persons, with irritation symptoms in the healthy population.	Persons with existing heart or respiratory ailments should reduce physical exertion and outdoor activity.
50	50% of NAAQS	75[b]	80[b]	5.0	120		Moderate[a]		
0		0	0	0	0		Good[a]		

[a] No index values reported at concentration levels below those specified by "Alert Level" criteria.

[b] Annual primary NAAQS.

[c] 400 ug/m^3 was used instead of the O_3 Alert Level of 200 ug/m^3.

SOURCE: U.S. Environmental Protection Agency, "Guidelines for Public Reporting of Daily Air Quality - Pollutant Standard Index."

TABLE 13-4

RANKING OF STANDARD METROPOLITAN STATISTICAL AREAS (SMSAs) USING POLLUTANT STANDARD INDEX (PSI) AIR POLLUTION DATA, 1975-77

Severity Class	SMSA	Number of "Unhealthful" Days (PSI over 100)		Number of "Very Unhealthful" Days (PSI over 200)	
		3-year average	Minimum-maximum annual days during 3 years	3-year average	Minimum-maximum annual days during 3 years
I (More than 150 days of PSI readings above 100)	Denver	157	143-182	30	20- 37
	Cleveland	225[a]	228-229	41[a]	12- 59
	Los Angeles	264	253-272	132	117-142
	Louisville	150	104-185	20	14- 31
	New York	273[b]	---	87[b]	---
	Riverside	193	174-185	106	88-122
II (100-150 days of PSI readings above 100)	Anaheim	120	95-134	38	17- 58
	Chicago	139	81-195	21	14- 31
	Philadelphia	103	79-143	12	7- 19
	St. Louis	123	97-141	21	13- 33
	Washington, D.C.	110	74-147	16	7- 26
III (50-100 days of PSI readings about 100)	Baltimore	64[a]	49- 79	18[a]	10- 25
	Houston	54	48- 64	9	4- 12
	Jersey City	74[b]	---	8[b]	---
	Nashville	59	39- 76	3	1- 5
	Portland	78	70- 83	7	3- 13
	Salt Lake City	82	60-110	18	9- 25
	San Diego	59	45- 74	6	4- 9
	San Jose	58	42- 81	8	0- 21
	Seattle	86	73- 95	5	4- 5
IV (25-50 days of PSI readings above 100)	Buffalo	41	31- 51	7	3- 11
	Cincinnati	41	20- 63	2	1- 4
	Dallas	26	18- 35	1	0- 2
	Dayton	33[a]	29- 37	1[a]	1- 2
	East Chicago	29	27- 31	-	---
	Hartford	34	25- 41	6	3- 8
	Indianapolis	33[a]	17- 49	2[a]	1- 3
	Milwaukee	35	32- 40	8	7- 8
	Sacramento	26	19- 38	1	0- 3
	San Francisco	33	24- 45	1	0- 2
V (0-25 days of PSI readings above 100)	Akron	14[b]	---	0[b]	---
	Grand Rapids	3[a]	1- 8	0[a]	0
	Honolulu	0[a]	0- 1	0[a]	0
	Kansas City	12	5- 23	3	0- 8
	Memphis	24	19- 24	3	0- 7
	Norfolk	13	9- 16	1	0- 2
	Oklahoma City	11[b]	---	0[b]	---
	Rochester	5	2- 8	0	0
	San Antonio	10[a]	8- 11	0[a]	0
	Syracuse	6	5- 7	1	0- 2
	Tampa	11	5- 19	1	0- 1
	Toledo	21[a]	14- 25	1[a]	1- 1

[a]Based on only 2 years of data.

[b]Based on only 1 year of data.

SOURCE: Data supplied by the U.S. Environmental Protection Agency.

APPENDIX

USE OF DIESELIZATION RATES IN MOBILE2 TO ESTIMATE LIGHT-DUTY VEHICLE AND LIGHT-DUTY TRUCK GASOLINE AND DIESEL POPULATIONS

For light-duty vehicles, the method used in MOBILE2 to estimate the nationwide vehicle registrations by model year is somewhat different than that presented in Table 3-1 of Section 3. Briefly, Table 3-1 uses data on the number of registered vehicles in each model year that are domestic versus import. Then, the nationwide percentage of these vehicles that are diesel-powered in each model year is used to estimate LDGV and LDDV registrations by model year.

In the input data for MOBILE2, a slightly different procedure is used to estimate LDGV and LDDV registrations. Total light-duty vehicle registrations by model year are multiplied by an estimated dieselization rate by model year to estimate LDDV registrations. The dieselization rate is the estimated fraction of light-duty vehicles which are diesel-powered in each model year. Current and projected dieselization rates used in MOBILE2 for light-duty vehicles are shown in Table A-1.

A similar procedure is used in MOBILE2 to estimate registrations by model year for LDGT1 and LDDT's. Estimated registrations by model year for these two vehicle categories are summed and dieselization rates (see Table A-2) are applied to estimate LDDT registrations by model year. The LDGT1 fleet sales fractions are assumed to be (1 - LDDT sales fraction) for each model year.

While it might seem to be more straightforward to use actual registrations by model year from MVMA or another source to estimate diesel versus gasoline registrations for light-duty vehicles and light-duty trucks, the rationale for the above methodology is that it can be used readily to project future year registrations, while the methods presented in Section 3 cannot.

It is important to note the difference between the MOBILE2 registration estimates and those shown in Section 3 of this report because the registration numbers are used in other sections. For instance, registrations can be used to estimate VMT fractions by model year and average miles per day per vehicle type. Calculations of VMT by model year are assumed to be the same for LDGV and LDDV and are shown in Table A-3. The sum of VMT by model year shown at the bottom of Table A-3 (11688.9×10^8) can be used to estimate both the average miles per day driven by LDGV and LDDV's and the fraction of total VMT driven by these vehicle types. Average miles per day driven by these vehicle types can be estimated by dividing the VMT total by the number of registered vehicles and the number of days in a year:

VMT per year	÷	365 days/year	÷	estimated registrations	=	average miles per day

$(11688.9 \times 10^8) \div 365 \div 102{,}939{,}000 = 31.1$ miles per day

Tables A-4 and A-5 illustrate how VMT by model year can be calculated for LDGT1 and LDDT using estimated nationwide registrations and annual mileage estimates. Note that the LDGT1 and the LDDT registrations are summed in each table by model year. These tables can be used to estimate the average miles per day driven by each vehicle type in the same manner as was illustrated above for light-duty vehicles. Thus, nationally, LDGT's are estimated to travel 26.3 miles per day and LDDT's are estimated to travel 29.8 miles per day.

TABLE A-1

FLEET SALES FRACTION* FOR 49-STATE
LIGHT DUTY DIESEL-POWERED VEHICLES

Model Years	Sales Fractions
Pre-1975	0.0
1975	0.002
1976	0.003
1977	0.005
1978	0.009
1979	0.028
1980	0.034
1981	0.047
1982	0.075
1983	0.089
1984	0.095
1985	0.114
1986	0.138
1987	0.165
1988	0.176
1989	0.187
1990	0.197
1991+	0.200

SOURCE: Murrell, J.D., Foster, J.A. and Bristor, D.M., June 1980.

*The estimated fraction of the light-duty vehicle fleet which are diesel-powered.

TABLE A-2

FLEET SALES FRACTION* FOR 49-STATE
LIGHT DUTY DIESEL-POWERED TRUCKS

Model Years	Sales Fractions
Pre-1978	0.0
1978	0.009
1979	0.028
1980	0.034
1981	0.047
1982	0.075
1983	0.089
1984	0.095
1985	0.114
1986	0.138
1987	0.165
1988	0.176
1989	0.187
1990	0.197
1991+	0.200

SOURCE: Murrell, J.D., Foster, J.A. and Bristor, D.M., June 1980.

*The estimated fraction of the light-duty truck fleet which are diesel-powered.

TABLE A-3

LDGV AND LDDV COMBINED
CALCULATION OF AVERAGE ANNUAL MILES DRIVEN

Model Year	Estimated Registrations ($\times 10^3$) (From Table 3-2)	Annual Mileage (From Table 2-1)	VMT by Model Year ($\times 10^8$)
1978	7,426	14,436	1,072.0
1977	10,382	13,903	1,443.4
1976	9,483	13,371	1,268.0
1975	7,291	12,838	936.0
1974	9,431	12,306	1,160.6
1973	10,559	11,773	1,243.1
1972	9,140	11,240	1,027.3
1971	7,326	10,708	784.5
1970	6,784	10,176	690.3
1969	6,087	9,643	587.0
1968	4,917	9,110	447.9
1967	3,589	8,577	307.8
1966	3,093	8,045	248.8
1965	2,369	7,513	178.0
1964	1,545	6,980	107.8
1963	1,021	6,447	65.8
1962	571	5,927	33,8
1961	256	5,382	13.8
1960	180	4,850	8.7
1959	1,489	4,317	64.3
	102,939		11,688.9

TABLE A-4

LIGHT-DUTY GASOLINE TRUCKS (0-6000 lbs. GVW)
CALCULATION OF AVERAGE ANNUAL MILES DRIVEN

Model Year	LDGT1 + LDDT Estimated Registrations (From Tables 3-10 & 3-11)	Annual Mileage (From Table 2-4)	VMT by Model Year ($\times 10^8$)
1978	1,246,650	15,610	194.6
1977	1,216,742	14,049	170.9
1976	1,100,385	12,488	137.4
1975	789,618	11,239	88.7
1974	1,169,956	10,147	118.7
1973	1,278,937	9,366	119.8
1972	977,635	8,585	83.9
1971	771,107	7,961	61.4
1970	564,147	7,493	42.3
1969	620,977	7,025	43.6
1968	588,557	6,556	38.6
1967	426,988	6,244	26.7
1966	450,072	5,932	26.7
1965	424,838	5,463	23.2
1964	33 ,321	5,151	17.3
1963	275,499	4,996	13.8
1962	195,416	4,683	9.2
1961	146,761	4,370	6.4
1960	133,608	4,371	5.8
1959	96,996	4,371	4.2
1959	62,318	4,371	2.7
	12,873,528 A-6		1,235.9

TABLE A-5

LIGHT-DUTY DIESEL TRUCKS (0-8500 LBS. GVW)
CALCULATION OF AVERAGE ANNUAL MILES DRIVEN

Model Year	LDGT1 + LDDT Estimated Registrations (From Tables 3-10 & 3-11)	Annual Mileage (From Table 2-4)	VMT by Model Year ($\times 10^6$)
1978	1,246,650	15,705	195.8
1977	1,216,742	15,077	183.4
1976	1,100,385	14,605	160.7
1975	789,618	13,978	110.4
1974	1,169,956	13,035	152.5
1973	1,278,937	12,093	154.7
1972	977,635	10,993	107.5
1971	771,107	9,738	75.1
1970	564,147	9,266	44.3
1969	620,977	7,381	41.9
1968	588,557	6,753	36.0
1967	426,988	6,125	23.5
1966	450,072	5,497	22.6
1965	424,838	5,031	19.4
1964	336,321	4,555	14.3
1963	275,499	4,240	10.4
1962	195,416	3,769	6.1
1961	146,761	3,141	4.6
1960	133,608	3,141	4.2
1959	96,996	3,141	3.0
1958	62,318	3,141	2.0
	12,873,528		1,398.4

REFERENCES FOR APPENDIX

Murrell, J.D., Foster, J.A. and Bristor, D.M. June 1980. "Passenger Car and Light Truck Fuel Economy Trends through 1980." SAE Technical Paper Series. Paper No. 800853.